

DuPont™ Vertrel® X-DA

Specialty Fluid

Removes Water and Contaminants Rapid, Spot-Free Drying Low Energy Consumption

Introduction

Water removal from processed parts is a major manufacturing step in the finishing of glass, ceramic, plastic, and metal components and assemblies. There are a variety of methods to accomplish this task. Some of the more common methods include evaporative, centrifugal, media absorbent, solvent absorption, and solvent displacement drying. Solvent displacement drying is a common and widely accepted method of water removal prior to plating, coating and other surface treatments of plastics, metals, mirrors, lenses, crystals, and ceramics. The method is particularly useful where reflective and refractive properties must be maintained.

The Vertrel® X-DA Displacement Drying System offers one-step, low-energy, spot-free drying that is efficient, safe to use, and environmentally responsible. Vertrel® X-DA consists of Vertrel® XF (2,3-dihydrodecafluoropentane), a fluorosurfactant additive, and an anti-static additive. It is nonflammable, has zero ozone-depletion potential (ODP), and a low global warming potential (GWP).

Vertrel® X-DA is accepted by the U.S. Environmental Protection Agency under the Significant New Alternatives Policy (SNAP) program as a substitute for ozone-depleting substances.

The physical properties of Vertrel® X-DA are shown in **Table 1** as compared to the Freon® T-DFC displacement drying fluid.

Table 1
Physical Property Comparison

Property ^a	Unit	Vertrel® X-DA	Freon® T-DFC
Molecular Weight	—	252	187
Boiling Point	°C	55	48
	°F	130	118
Liquid Density	g/cc	1.58	1.56
	lb/gal	13.2	13.1
Vapor Pressure	mm Hg	226	226
	psia	4.4	4.4
Surface Tension	dyne/cm	14.1	17.3
Viscosity	cPs	0.67	0.67
Freezing Point	°C	-80	-35
	°F	-112	-31
Heat of Vaporization at Boiling Point	cal/g	31	35
	Btu/lb	56	63
Heat Capacity	cal/g°C	0.27	0.22
	Btu/lb°F	0.27	0.22
Flash Point			
Closed Cup ^b	°C	None	None
Open Cup ^c	°C	None	None
Vapor Flammability in Air			
	LEL	vol%	None
	UEL	vol%	None

^aAt 25°C (77°F) except where indicated.

^bTag Closed Cup Tester (ASTM D 56).

^cTag Open Cup Tester (ASTM D 1310).



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The miracles of science™

Vertrel® Displacement Drying

The Vertrel® Drying System operates on the displacement principle. The process uses the high density and low surface tension (wetting ability) of the Vertrel® XF fluid, a hydrophobic fluoro-surfactant additive that promotes water separation, and an anti-static additive to enhance the spot-free drying of electrically non-conductive parts such as glass lenses and mirrors. Used in a 2- or 3-sump cascading process similar to a vapor degreaser, the Vertrel® Displacement Drying System can effectively remove large or small quantities of water from metal, glass, or plastic parts and assemblies.

Water, along with dissolved contaminants, adheres to surfaces in droplet form. When a wetted part is immersed in the Vertrel® X-DA, the higher density, lower surface tension, and unique properties of the fluorosurfactant additive allow the Vertrel® X-DA to penetrate beneath the water droplet. Buoyancy forces will help lift the agglomerated droplets away from the surface of the part and the water will rise to the surface of the heavier, hydrophobic Vertrel® X-DA drying fluid. **Figure 1** illustrates this sequence.

The water flows from the surface of the drying sump over a weir, into a gravity water separator, and is rejected from the dryer through the water drain. The parts are then removed from the drying fluid and passed through one or more cascading baths of Vertrel® XF to dissolve and remove residual surfactant from the surface. Upon removal, the parts are dry and spot-free. Displacement drying systems are commercially available and operate much the same as vapor degreasing equipment except that water separation and removal capabilities are greatly enhanced. **Figure 2** illustrates a typical displacement drying system.

Displacement Drying Advantages

Spot-Free Drying

Evaporative or hot air drying generally will deposit a residue of any nonvolatile material that was suspended or dissolved in the water. Centrifugal drying is usually effective only in removing gross amounts of water from free draining parts. A slight water film usually remains, which must be removed by other means. Media-absorbent drying transfers moisture from the

parts to a porous medium such as sawdust or corn-cobs, which then must be disposed of or dried through evaporation. The parts must then be further processed to remove residue deposited by the absorbent media.

Displacement drying depends on the use of a relatively high specific gravity drying fluid to encourage rapid displacement of water along with its water-soluble contaminants. At the low operating temperature (55°C [130°F]) of this system, virtually no water evaporates from the wet parts; therefore, water-soluble salts cannot be deposited on their surfaces. This permits water to float to the surface of the solvent, where it is continuously swept away by the equipment, enabling dried parts to be removed without passing through a layer of contaminated water.

This combination of low-temperature boiling action, immiscibility with water, and high specific gravity is the major reason for the dry, spot-free condition of parts emerging from the Vertrel® X-DA Displacement Drying System.

Low Energy Consumption

Evaporative or hot air drying employs heat to remove water by changing it from a liquid to a vapor. This method requires large amounts of energy to operate because approximately 1,000 Btu (0.293 kWh) are required to evaporate each pound of water. The Vertrel® X-DA Displacement Drying System operates at a low operating temperature (55°C [130°F]) and consumes significantly less energy.

Other Advantages

The Vertrel® X-DA Displacement Drying System offers these advantages:

- Removes water in pH ranges between 5 and 9.
- Removes hard water.
- Is easily rinsed because of lower drying agent concentrations.
- Drying agent has limited water solubility and has no vapor pressure, so it will remain in the boil sump.
- Reduces cycle time by elimination of air drying step.

Figure 1. Fluorocarbon Displacement Drying Sequence

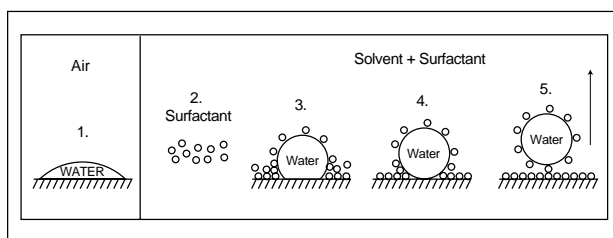
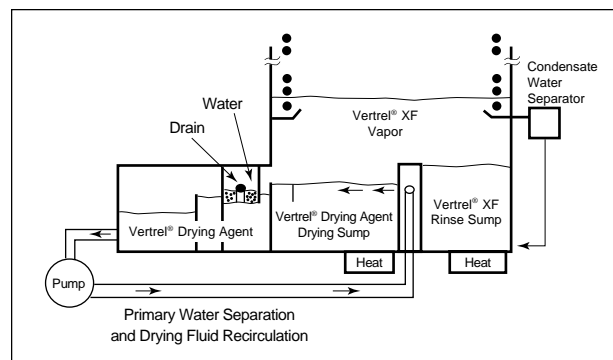


Figure 2. Displacement Drying System



Other Solvent Drying

There are two ways in which solvents can remove water from surfaces: (1) by displacing it through preferential wetting of the parts surfaces and subsequent separation of the water from a more dense, water-insoluble solvent such as Vertrel® X-DA or (2) by dissolving the water—as with polar solvents such as alcohol or acetone. Vertrel® X-P10 is such a blend. It consists of Vertrel® XF (non-soluble in water) and isopropyl alcohol, has no flash point, and is designed for absorption drying. For further information see DuPont's Vertrel® X-P10 Product Bulletin.

Anti-Static Additive

Use of an anti-static additive in the drying fluid in combination with the surfactant may be necessary when drying electrically non-conductive parts such as glass lenses and mirrors to prevent spots and stains. Vertrel® XF has the utility as a dielectric fluid, meaning it is a poor conductor of electric current and, therefore, does not easily dissipate static charge. The boiling and general circulation of the drying fluid creates static charge, particularly in the latter stages of the drying process when most of the water has been removed from the system. This charge collects on the surface of the non-conductive part and can prevent the release of the last water droplet traces which dry in place leaving water spots and stains.

The anti-static additive is a polar compound soluble in Vertrel® XF which increases the conductivity and dissipates the static charge. The anti-static additive has some volatility that makes it effective in both the drying and rinse stages of the process and further has low water solubility.

Drying Procedure

Following is a brief suggested procedure for drying:

1. Place parts in open-mesh holder and lower into drying sump containing Vertrel® X-DA drying agent boiling at 55°C (130°F). Usually, a 1- to 3-minute immersion is sufficient depending on the size, configuration, and other characteristics of the parts. Shake the holder up and down a few times to help dislodge any trapped water between parts. Also, make certain that parts with recesses or cups are oriented so released water can float up to the surface of the bath.
2. Remove parts from the Vertrel® drying agent and hold over the drying sump to permit excess solvent to drain back into sump. Lower into the Vertrel® XF sump for rinsing. Shake holder. If equipment with a second Vertrel® XF rinse sump is employed, repeat the rinsing step.
3. At the end of the rinse, hold parts in the vapor zone. After dripping stops, remove from the dryer, and parts will be dry, spot-free, and ready for further processing.
4. Ultrasonics (in the drying and/or rinse sumps) can increase the efficiency of the drying process. A spray rinse of the parts with a spray lance or ring, while they are in the vapor zone, increases the efficiency of the final step. Spraying of parts should be done under the vapor blanket to minimize emissions.
5. The Vertrel® Drying System depends on floating away the displaced water from wet parts. Drying cannot take place if water is trapped inside small cracks and crevices or if orientation traps water under cup-like cavities. These problems are often solved by shaking or rotating parts in the drying bath. The Vertrel® Displacement Drying System is not recommended for fibrous or porous parts, as they present special problems in both water displacement and excessive solvent carryout.

Equipment

Consideration should be given to the purchase of new or retrofitting of existing vapor degreasing equipment to provide vapor containment technology that enables safe and economical use of Vertrel® X-DA. Modern vapor containment systems have higher freeboard and a secondary set of low temperature (–29°C [–20°F]) condenser coils to greatly reduce vapor losses.

Fluids Required in the System

Two different fluids are required in the Vertrel® Displacement Drying System.

- Vertrel® X-DA—The drying agent used in the boiling sump. It consists of Vertrel® XF plus a fluorosurfactant additive and an anti-static additive to give the water-displacing action. It is used only for the initial charge of the drying sump and recirculating tank system, and for make-up.
- Vertrel® XF Fluid—Fluid used to charge the rinse sumps. Its primary purpose is to rinse off residual drying agent left on parts coming from the boiling water removal sump. Thereafter, condensed Vertrel® XF vapors from the boiling sump will act to keep the fluid in the rinse sumps clean and at the proper level.

Both fluids are nonflammable and offer a drying system compatible with most plastics, elastomers, metals, and other materials of construction.

Because displaced water, with its water-soluble contaminants, automatically floats quickly out of the drying sump and down the drain, the Vertrel® drying bath retains its effectiveness over long periods of use. Due to the limited solubility of surfactant in water (75 ppm), some surfactant loss can be expected. This can be compensated for by adding Vertrel® X-DA when additional solvent is needed in the drying sump. The surfactant is effective over a wide range of concentrations (0.02 to 0.2%).

Compatibility

The compatibility of materials with Vertrel® X-DA is virtually the same as with Vertrel® XF. Both products have a broad compatibility range. **Tables 2 and 3** summarize test results from short-term exposures of unstressed plastics and elastomers simulating a typical drying cycle. Long-term compatibility data simulating exposure of equipment construction materials is available from DuPont upon request.

Elastomer swelling and shrinking will, in most cases, revert to within a few percent of original size after air drying. Swell, shrinkage, and extractables are strongly affected by the compounding agents, plasticizers, and curing used in the manufacture of plastics and elastomers. Therefore, prior in-use testing is particularly important.

Table 2
Plastic Compatibility
Immersion: 15 Minutes at Room Temperature

Compatible	
Polyethylene	ABS
Polypropylene	Acetal
Polyester, PET, PBT	Epoxy
Polyphenylene Oxide, PPO	Ionomer
Polyimide, PI, PEI, PAI	Liquid Crystal Polymer
Polyetherketone, PEK	Phenolic
Polyaryletherketone, PEEK	PVC, CPVC
Polysulfone	PTFE, ETFE
Polystyrene	
Polyarylsulfone	
Polyphenylene Sulfide, PPS	

Incompatible^a

Cellulosic	Acrylic
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^a Material composition varies depending upon compounding agents, plasticizers, processing, etc. Specific materials should be tested for compatibility with solvent.

Table 3
Elastomer Compatibility
Immersion: 15 Minutes at Room Temperature

Compatible	
Buna N, NBR, Nitrile	Buna S, SBR, GRS
Butyl Rubber, IIR	Chlorosulfonated PE
EPM, EPDM, NordeI®	Polysulfide
Natural Rubber, Isoprene	Neoprene
Urethane	Silicone
Viton® B	

Incompatible^a

None Tested

^a Material composition varies depending upon compounding agents, plasticizers, processing, etc. Specific materials should be tested for compatibility with solvent.

Metals and Other Compatibility

Vertrel® X-DA is compatible with aluminum, brass, copper, stainless steel, and zinc.

Vertrel® X-DA is not compatible with strong bases; therefore, contact with highly basic process materials is not recommended.

Exposure Limits

Data from acute toxicity studies has demonstrated that Vertrel® X-DA has low toxicity. Vertrel® X-DA is a slight skin and eye irritant and has low acute inhalation toxicity. **Table 4** shows the applicable exposure limits for Vertrel® X-DA.

Table 4
Exposure Limits

Component	Limit, ppm	Type
Vertrel® XF	AEL ^a 200 400	8- and 12-hr TWA Ceiling ^b
Fluorosurfactant	AEL ^c —	8- and 12-hr TWA
Anti-Static Agent	TLV ^d 20	8-hr TWA
	AEL 10	8- and 12-hr TWA
Vertrel® X-DA	AEL ^{a, b} 144	Calculated ^e

^a AEL (Acceptable Exposure Limit) is an airborne inhalation exposure limit established by DuPont that specifies time-weighted average concentrations to which nearly all workers may be repeatedly exposed without adverse effects.

^b A ceiling limit is the concentration that should not be exceeded during any part of the working day. The ceiling limit for individual components applies to the blend product as well.

^c None established.

^d TLV (Threshold Limit Value) is an air-borne inhalation exposure limit established by the American Conference of Government and Industrial Hygienists (ACGIH) that specifies time-weighted average concentrations to which nearly all workers may be repeatedly exposed without adverse effects.

^e Calculated in accordance with ACGIH formula for TLVs for mixtures.

Safety/Flammability

Vertrel® X-DA exhibits no closed cup or open cup flash point, and is not classified as a flammable liquid by NFPA or DOT. In addition, the product has no vapor flammability limits in air.

Flash point data and limits of flammability in air provide the user with additional information that should be used as elements of a fire risk assessment and to determine guidelines for the safe handling of volatile chemicals. Users should assure compliance with NFPA standards and local fire codes.

Recovery

Vertrel® X-DA is a blend of Vertrel® XF, a fluoro-surfactant, and an anti-static agent. The anti-static agent has some volatility, so the Vertrel® XF, and some fraction of the anti-static agent, are recoverable by off-line and in-line distillation equipment such as a vapor degreaser or still. This recovered material is suitable for reuse in the rinse sumps. The fluoro-surfactant, critical for effective drying performance, has no vapor pressure, and will remain in the boil sump or still bottoms.

The presence of soil may alter the characteristics of the material during the recovery operation. Recovery should be monitored closely to ensure operating levels are maintained. Users should test the spent Vertrel® X-DA to ensure proper classification for waste disposal.

Storage/Handling

Vertrel® X-DA is thermally stable and does not oxidize or degrade during storage. Store in a clean, dry area. Protect from freezing temperatures. If solvent is stored below -10°C (14°F), mix prior to use. Do not allow stored product to exceed 52°C (125°F) to prevent leakage or potential rupture of container from pressure and expansion.

Consideration should be given to retrofit of existing, or purchase of new, vapor degreasing equipment to provide vapor containment technology that enables safe and economical use of Vertrel® X-DA.

Drum pumps are recommended to dispense Vertrel® X-DA from its container. Refer to the Material Safety Data Sheet for specific handling precautions and instructions.

Environmental Legislation

Vertrel® specialty fluids have “zero” ozone depletion potential and low global warming potential (**Table 5**). They are used as alternatives to CFC-113, methyl-chloroform, hydrochlorofluorocarbons (HCFCs), and perfluorocarbons (PFCs) in many critical cleaning, drying, carrier fluid, and other high-value specialty uses where reliability is paramount.

Vertrel® X-DA is accepted by the U.S. Environmental Protection Agency (EPA) under the Significant New Alternatives Policy (SNAP) program, as a substitute for ozone-depleting substances. Vertrel® X-DA is VOC compliant under the California South Coast Air Quality Management District (SCAQMD) regulations, which require VOC content less than 50 g/L of solvent.

The components of Vertrel® X-DA are listed in most country chemical inventories, such as TSCA in the U.S., ELINICS in Europe, Chemical Substances Control Law (MITI/MHW) in Japan, DSL (notified) in Canada, NICNAS in Australia, and TCCL in Korea.

Vertrel® X-DA is not a hazardous air pollutant (HAP), and therefore not subject to NESHAP regulation. Spent Vertrel® X-DA is not a RCRA characteristic or listed waste. However, addition of contaminants could change that status. Vertrel® X-DA is not included in the SARA Title III Section 313 list of toxic chemicals, and is not subject to SARA Title III (EPCRA) reporting requirements.

Table 5
Environmental Properties

Property	Vertrel® X-DA
Ozone-Depletion Potential (ODP)	0
Global Warming Potential (GWP/100 yr ITH)	1292
Volatile Organic Compounds (VOC, g/L)	8

Packaging and Availability

Vertrel® X-DA is available in 55-gal (208-L) drums with a net weight of 660 lb (229 kg) and in 5-gal (19-L) pails with a net weight of 60 lb (27 kg). One-gallon and smaller samples in glass containers are available on request. Customers are encouraged to secure samples now for compatibility and performance testing.

Specifications

Composition and specifications are shown in **Table 6**. All components are listed in the TSCA Inventory.

Table 6
Vertrel® X-DA Specifications

Vertrel® XF, wt%	99.4 ± 0.1
Fluorosurfactant, wt%	0.1 ± 0.025
Antic-Static Agent, wt%	0.5 ± 0.1
Appearance	Clear, colorless

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